However, neither the BCPM 1.1 nor the Hatfield 4.0 rural approaches captured actual customer location with adequate accuracy. Given this dilemma, the BCPM developers recognized the need to create an innovative approach that could locate accurately customers in all areas. To accomplish this, BCPM 3.1 uses a reformulated geographic entity - the dynamic grid.

The Cost Proxy Model (CPM©) used a 1/100 of a degree longitude and latitude grid. This standardized the geographic unit of measure for modeling, simplified the engineering algorithms, removed the modeling errors from "squaring" CBGs, and allowed the roll-up of the geographic grid entity into almost any entity desired by the user. BCPM 3.1 further enhances the CPM's grid approach by combining it with CSA engineering constraints. The resulting grid unit is dynamic in the sense that this grid varies in size to ensure that the number of customers included in a grid takes into account CSA guidelines[19]. Furthermore, the maximum grid size is constrained so that the limitations of copper distribution are not exceeded.

To illustrate the rural data and the various approaches to locating rural customers, Appendix A, Exhibit 1, provides satellite maps for six random CBGs in the lowest density group, i.e. less than five housing units per square mile. Note the variability in the degree of clustering across these CBGs. Appendix A, Exhibits 2 and 3, provide the comparison of Hatfield Model 4.0's, BCPM 1.1's, and BCPM 3.1's characterization of customer location for two of these six CBGs. Although this is not representative of all rural areas, these areas were randomly selected and seem to demonstrate BCPM 3.1's superiority in locating customers.

5.3 Methodology

The following discussion provides highlights of the methodology employed in generating the appropriate grid configuration associated with a given wire center. In general, a series of reaggregation steps creates ultimate grids of various sizes, consistent with an efficient network design. Each grid's size, cost characteristics, and number of lines is integrally linked to telephone engineering CSA guidelines. In addition, the construction of these

[19] Lucent Technologies Outside Plant Engineering Handbook, Section 3.

grids takes into account the actual road network to more accurately reflect the location of customers within a CB. (Additional detail on this process is provided in Appendix B.)

The customer location process comprises six major steps:

1) Establish Wire Center Boundaries
2) Assign Census Block Demographic Data to Wire Centers
3) Establish Microgrids Within Wire Center Boundaries
4) Assign Census Block Data to Microgrids
5) Aggregate Microgrids to Ultimate Grids
6) Establish Distribution Quadrants

5.3.1 Wire Center Boundaries

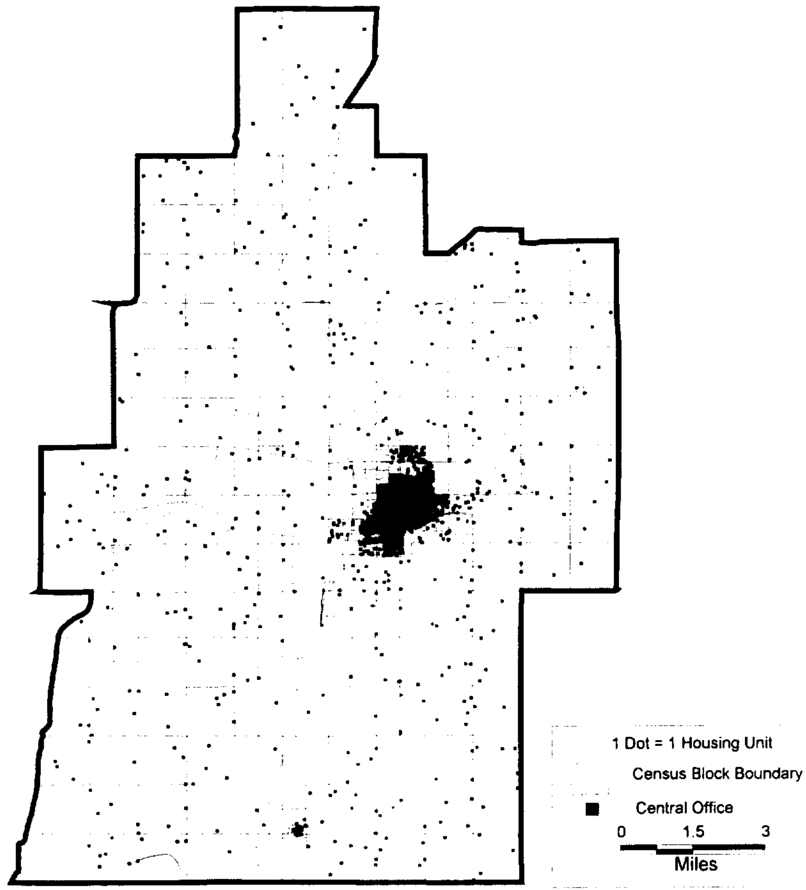
The first step in accurately establishing customer location is the specification of the appropriate wire center boundaries. In BCPM 1.1, wire center boundaries were established based on the aggregate area of CBGs whose centroids were assigned to that particular wire center. In contrast, BCPM 3.1 relies on wire center data obtained from BLR. Appendix A, Exhibit 4, compares actual wire center boundaries with the wire center boundaries of BCPM 1.1 and BCPM 3.1 for an Iowa wire center.

5.3.2 Assign Census Block Data to Wire Centers

The second step is to use the CB level of data that falls within the corresponding wire center boundary. For the occasional CB that crosses wire center boundaries, housing and business data are apportioned to the respective wire centers. If the CB is less than 1/4 of a square mile, the apportionment is based on the relative proportions of land area. If the CB is greater than 1/4 of a square mile, the apportionment is based on the relative proportions of road mileage. Appendix A, Exhibit 5, depicts CBs within the Waukon, Iowa wire center. Figure 5.1 (below) displays CB and Housing Unit Density for the Red Oak, Iowa Wire Center. The black areas at the center of the map are Census Block boundaries so close together as to be indiscernible at the current map scale.

Figure 5.1

Housing Unit Density – Census Blocks
Red Oak, Iowa

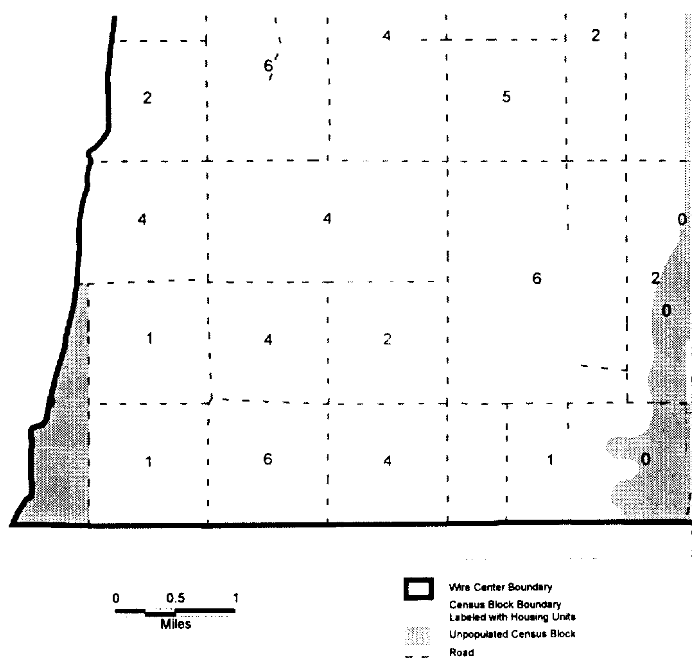


The Bureau of the Census establishes CB boundaries based on roads and natural borders such as rivers. The CB data that provides household and housing unit line counts reflects 1990 Census data that have been updated based upon 1995 Census statistics regarding household growth by county. BCPM 3.1 also uses business line data obtained from PNR and Associates (PNR). Although some of the business lines are defined only at the Census Tract and CBG level,[20] PNR has successfully assigned approximately 85%

[20] This is typical of attempts to geocode customer locations based on address data.

of the business customers to specific CBs. Figure 5.2 (below) shows an example of the assignment of CB's, with associated households, to the Red Oak wire center.

Figure 5.2
Example of Assignment of Census Blocks to a
Portion of the Wire Center
Rural Red Oak, Iowa



This diagram displays several Red Oak Census Blocks that have been labeled with the number of housing units each contains.

5.3.3 Establishing Microgrids

It is necessary to establish microgrids so that populated areas can be aggregated appropriately into telephone engineering CSAs. There are two phases of the grid process. The first phase entails assigning CB data to microgrids. "Microgrid" refers to the smallest grid size used in the grid process. A microgrid is 1/200th of a degree latitude and longitude. This corresponds to approximately 1,500 feet by 1,700 feet latitude and longitude.[21] The entire serving wire center is partitioned into microgrids. Thus, each CB within the serving wire center is overlayed with microgrids (unless the entire CB falls within a single microgrid). Smaller CBs, typically located in the denser, urban areas or the town portions of rural exchanges, are aggregated into microgrids while larger CBs located in the outlying portions of the rural areas may span multiple microgrids.

5.3.4 Apportioning Census Block Data to Microgrids

Since household and business line data[22] are assigned at the CB level, CB line data must be apportioned to microgrids when the CBs are larger than their corresponding microgrids. Two approaches are used to apportion this data to the microgrids, depending on the size of the CB. For CBs whose area is less than 1/4 square mile, (2,640 feet by 2,640 feet), encompassing approximately three to four microgrids, household and business line data is apportioned based on the land area of the microgrid used relative to the CB's total area.[23]

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[21] Due to the curvature of the earth, these dimensions vary depending on the latitude and longitude where they are derived. These measurements are used only to give the reader a sense of relative size.

[22] Household data includes housing unit and household information from the Census Bureau. Business line counts are obtained from PNR.

[23] For a microgrid that is fully encompassed by a CB, i.e. 100% of the microgrid's area is encompassed within the CB, the area covered by that one microgrid is (1,500ft. x 1,700 ft) = 2,550,000 sq. ft. If the total area of the CB is 5,100,000 sq. feet, then the fraction of land area of the CB encompassed by that microgrid is(2,550,000sq ft. /5,100,000sq. ft.) = .5 of the area. Thus, 50% of the household and business line data is apportioned to that microgrid.

If only a portion of a microgrid is encompassed by the CB, e.g. 80% of the microgrid is encompassed by the CB, then the area covered by that one microgrid is .8x(1,500ftx1,700ft) = 2,040,000 sq. ft. If the area of the CB is 5,100,000sq. ft., then (2,040,000 sq. ft./5,100,000 sq. ft.) =.40 In this case, .4 or 2/5ths of the household and business line data is apportioned to the microgrid.

For CBs with an area greater than 1/4 square mile, household and business line data are apportioned based on relative road lengths using actual road data obtained from TIGER/Line files [Topologically Integrated Geographic Encoding and Referencing from the US Census Bureau]. That is to say, the line data is apportioned based on the road length contained within a microgrid that traverses that CB, relative to the total road length within that CB. Since roads are used to locate customers, certain roads where customers are unlikely to reside, have been excluded from the road data.[24] To illustrate the apportionment of household and business line data to micrograms based on relative road lengths, assume that the total road length associated with a particular CB is 60 miles and that 20 of those miles traverse a particular microgrid. Since (20 miles / 60 miles) = .333, 1/3 of the household and business line data is associated with that particular microgrid. At the end of phase one of the grid process, the total census housing unit and PNR business line data associated with a wire center have been apportioned to each of the microgrids comprising that serving wire center.

5.3.5 Reaggregating Microgrids into Grids

The fifth phase of the grid process entails aggregating these microgrids into larger grids as appropriate. The purpose of developing variable size grids is to simulate the basic telephone plant engineering units of a CSA. The ultimate size of the larger grids depends upon housing and business line data and technological constraints on the reasonable size of CSAs. In general, the largest ultimate grid size is 1/25th of a degree latitude and longitude in size or approximately, 12,000 to 14,000 feet per side.[25] Hereafter, grids 1/25th of a degree latitude and longitude are referred to as macrogrids. The macrogrid constrains the maximum copper distribution length from the DLC to the customer to 12,000 feet, in most cases. Occasionally, however, due to placement of the DLC or re-aggregation of the isolated grids (discussed later), the length of a cable from the DLC to the customer may exceed 12,000 feet. In these cases, cable gauge is adjusted from 26 to

[24] Road data used in BCPM 3.1 exclude all limited access highway segments; all highway and road segments that are in a tunnel or in an underpass; vehicular "trails" and roads passable only by 4 wheel drive vehicles; highway access ramps; ferry crossings; pedestrian walkways and stairways; alleys for service vehicles; and driveways and private roads.

[25] Ultimate grids may exceed this size if isolated grids are combined with grids 12,000 feet by 14,000 feet per side to generate an ultimate grid. (This is discussed later.)

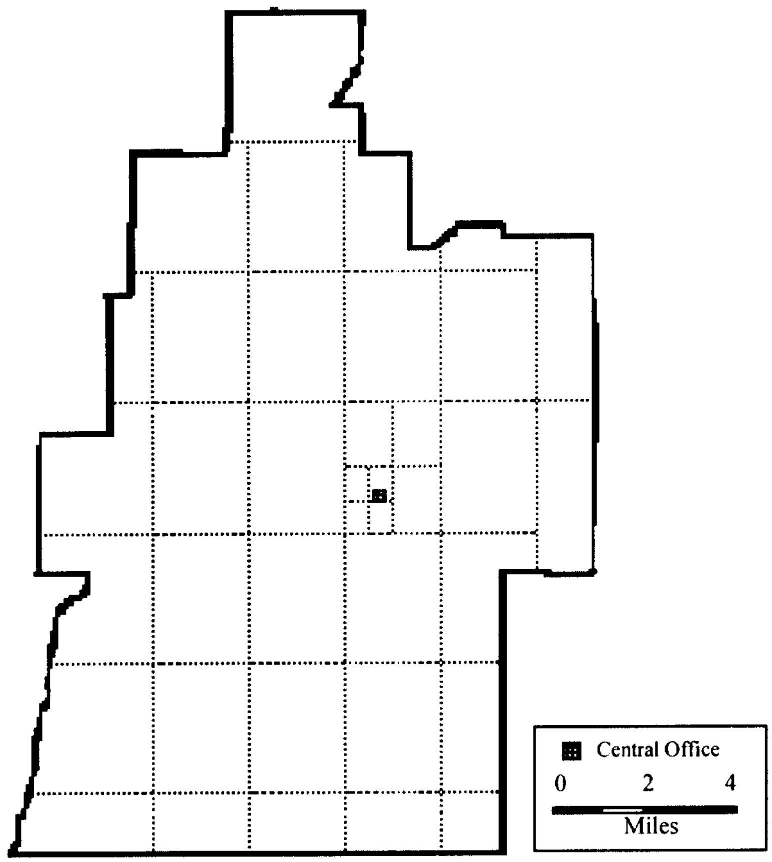
24 and extended range line cards are used to accommodate distribution cable lengths up to 18,000 feet.

At first blush, it may seem reasonable to start with microgrids and expand them as appropriate to satisfy technological constraints. However, such an approach results in a large number of remaining microgrids dispersed among larger grids. To reduce the potential for isolated microgrids, BCPM 3.1 establishes fixed grid boundaries by overlaying macrogrids upon the microgrids. 64 microgrids constitute a macrogrid. These macrogrid boundaries constitute the maximum size grid associated with each respective group of 64 microgrids.

The ultimate grid size utilized essentially reflects the manner in which customers are clustered. Modeling grids that vary in size is tantamount to allowing clusters of customers associated with a particular CSA to vary in density and dispersion.

The algorithm for determining the ultimate grids is actually a multistage process built to satisfy engineering constraints, minimize processing time, and simplify computer code. The following provides the essence of the grid algorithm. (For a more detailed discussion of the general rules for grid aggregation see Appendix B.) The derivation of ultimate grids is essentially an iterative process where partitioning occurs if the number of lines within a grid is too large, or if other technological constraints become binding. The macrogrid is partitioned into smaller grids, if warranted, based on household and business line data associated with the underlying microgrids, and CSA guidelines. The iterative process partitions the macrogrid into four equally sized subgrids. In some instances, these subgrids, which are 1/50th of a degree latitude and longitude in size, become the ultimate size for that composite of microgrids. In other instances, the number of lines within a subgrid is still too large. In those instances, additional sub-partitioning occurs for the subgrids. Additional sub-partitioning continues to occur until all grids satisfy line size and technological constraints. The smallest grid allowed is the 1/200th of a degree latitude and longitude, the microgrid. The resulting ultimate grids have a composite household and business line count equal to the sum of the household and business lines for the associated underlying microgrids. The ultimate grids for Waukon, Iowa are depicted in Appendix A, Exhibit 5. Ultimate grids for Red Oak, Iowa are shown in figure 5.3a (below).

Figure 5.3a
Ultimate Grids - Red Oak, Iowa



It is possible that, after completing this iterative process, small groups of isolated microgrids remain within the macrogrids, that have less than 100 lines associated with each group. Such isolated microgrids do not warrant placement of a CSA within a group. Instead, these small groups of microgrids are aggregated with ultimate grids within the macrogrid in which they reside, that are equal or larger in size, and are located closest to the road centroid of each small group of microgrids.

Partial grids arise from microgrids that intersect the wire center's boundaries and do not lie within a macrogrid. Partial grids with line demand less that 100 and smaller than 1/5th of a macrogrid in area, and therefore, not supportive of a CSA for that partial grid, are aggregated with the adjacent macrogrid that constitutes the longest border along that partial grid. The process described above is repeated for each expanded macrogrid.

Figure 5.3b (below) illustrates the census blocks associated with ultimate grids for Red Oak, Iowa, as a result of assigning microgrids to ultimate grids.

Figure 5.3b
Census Blocks and Ultimate Grids
Red Oak, Iowa

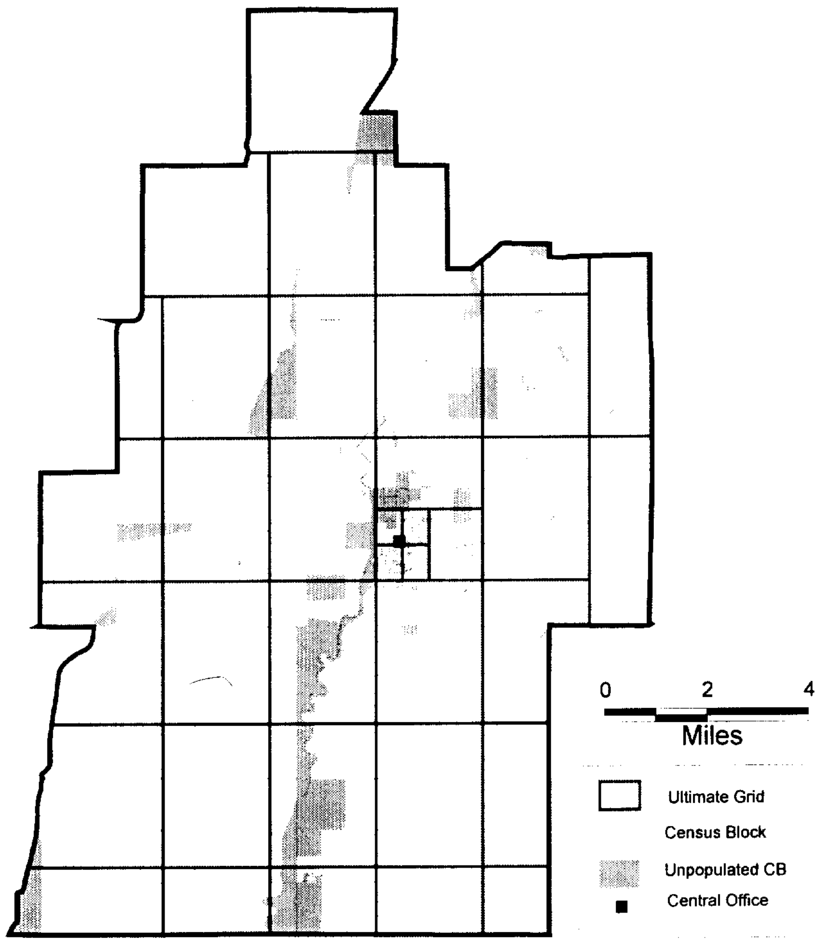
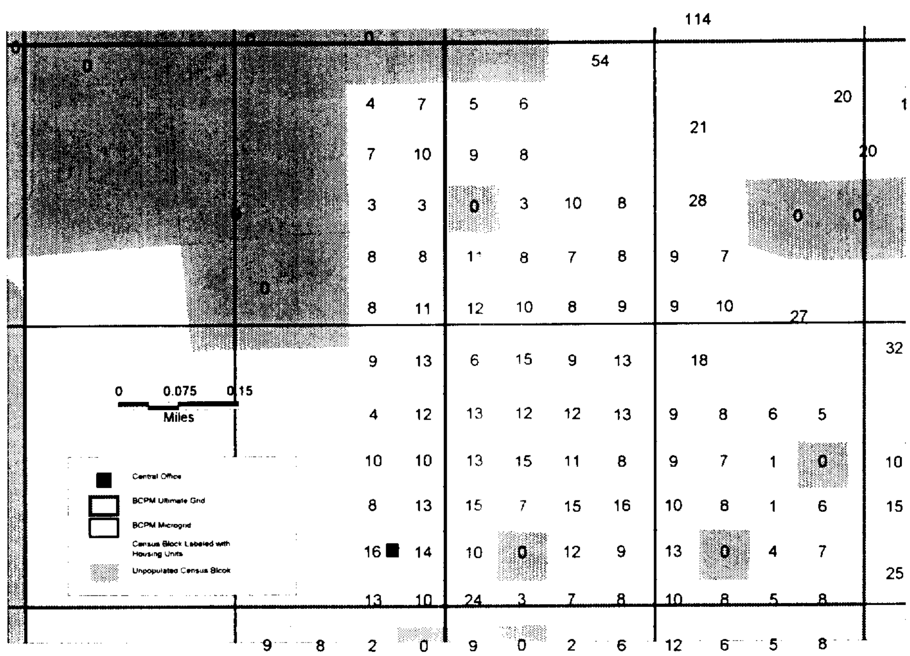


Figure 5.3c is a closer look at the relationships between CBs, microgrids, and ultimate grids. Clearly, the model is assigning or apportioning CB data in a way that consistently creates grids sized to meet CSA guidelines, whether the CBs contain high or low population densities. In the urban center, each microgrid contains numerous CBs, with several microgrids making up an ultimate grid. In the rural area, each ultimate grid contains relatively few CBs, as illustrated by Figure 5.3d.

Figure 5.3c
BCPM Ultimate and Microgrid Size
Urban Red Oak, Iowa

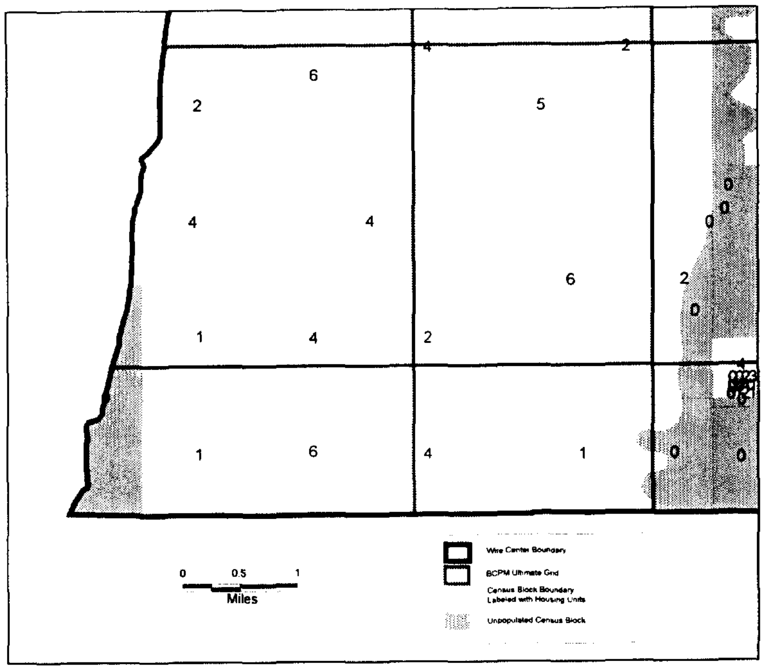
Urban Red Oak



This map displays the size of Census Blocks within the urban center of the Red Oak wire center, relative to microgrids in the same area. This diagram depicts two ultimate grids, each containing four microgrids. Please notice that the microgrids are much larger than the Census Blocks they contain. It should be apparent from this view that most of the urban CBs are directly assigned to the microgrid and do not require use of the allocation process. Furthermore, this association between Census Blocks and microgrids is retained in the final customer location step, establishing the distribution quadrants. This ensures that BCPM places cable to the actual customer locations, rather than moving the customers to some hypothetical distribution cable network.

Figure 5.3d
BCPM Ultimate Grid Size
Rural Red Oak, Iowa

Rural Red Oak



Census Blocks in this rural portion of the Red Oak wire center are smaller than the ultimate grids that contain them. In this rural area with very low density, the ultimate grid is the most relevant unit of measure. This is because typically, only one FDI (co-located with the DLC system) is placed per ultimate grid. Note that at this level many Census Blocks are wholly assigned, not allocated, to their ultimate grids. This ensures that the model maintains an accurate representation of customer location.

5.3.6 Establishing Distribution Quadrants Within Each Grid

Once the ultimate grids have been established, each ultimate grid[26] is segmented into four distribution quadrants. The latitude and longitude coordinates of the distribution quadrants are determined by first establishing the road centroid of the grid.[27] Figure 5.4a (below) displays the road system and road centroids for ultimate grids in Red Oak, Iowa. Distribution quadrants within the ultimate grid are centered about this road centroid.

Figure 5.4a

Road System and Road Centroids
Red Oak, Iowa

[26] Since data is not defined below the microgrid level, the microgrid cannot be segmented into quadrants.

[27] The road centroid is calculated as the average horizontal and vertical point of all roads in the defined area.

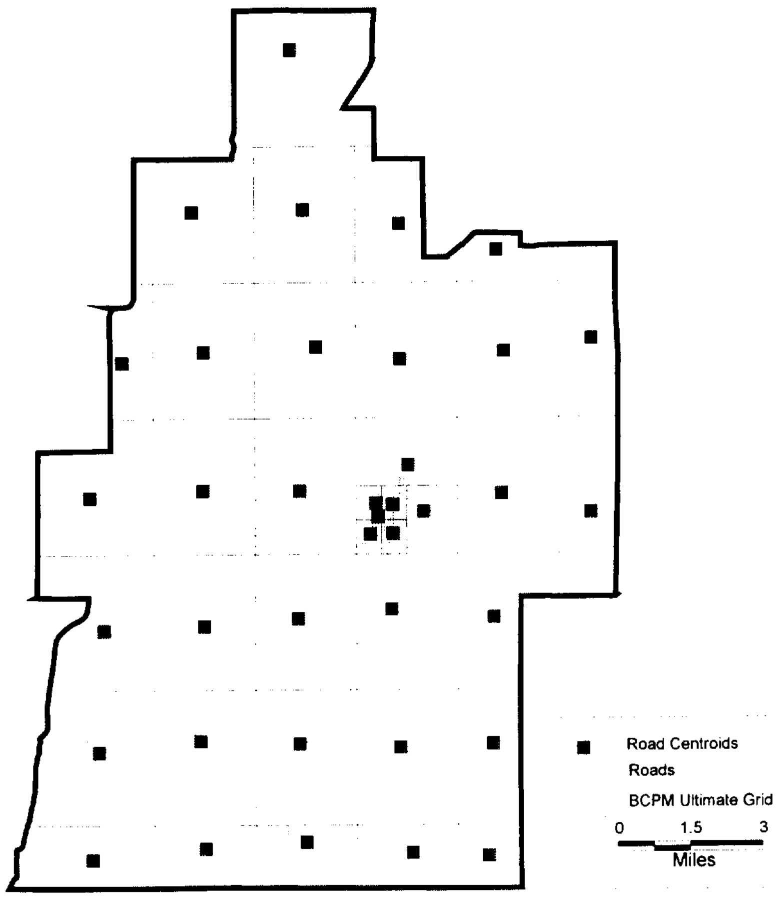
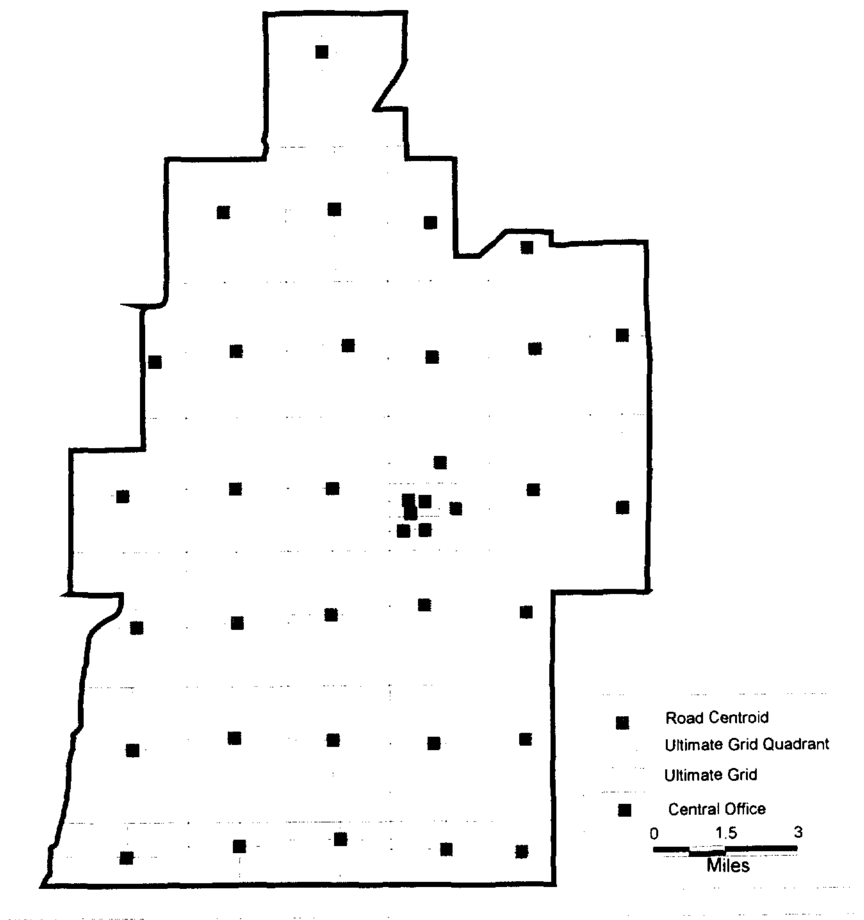

Road Centroids
Roads
BCPM Ultimate Grid
0
1.5
3
Miles

Figure 5.4b (below) shows the resulting distribution quadrants.

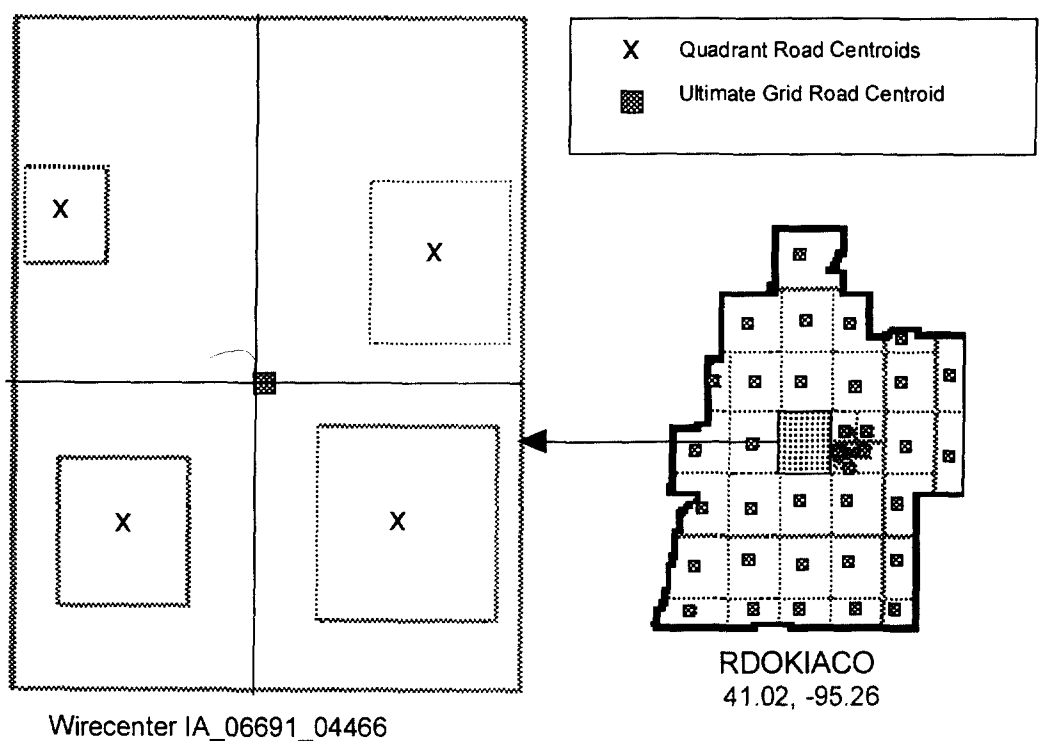
Figure 5.4b

Road Centroids and Distribution Quadrants
Red Oak, Iowa



Within each distribution quadrant, another road centroid is established. If a distribution quadrant does not contain any roads, that distribution quadrant is simply treated as an empty distribution quadrant. For each non-empty distribution quadrant, the total area that falls within a 500-foot buffer along each side of the roads within that distribution quadrant is calculated. The road-reduced area is modeled as a square whose size is equal to the total road buffer area. The road-reduced area can vary in size and location among distribution quadrants within an ultimate grid. The center of each distribution quadrant's square road-reduced area is placed at the road centroid of the distribution quadrant. (See Figure 5.5, below, for an example of quadrants for an ultimate grid in Red Oak, Iowa.) Within each of these road-reduced areas, the customer data, apportioned at the microgrid level for housing units and business lines, is retained at the distribution quadrant level and subsequently passed to the distribution algorithms for cable design.

Figure 5.5
Road Reduced Areas Centered
About the Road Centroids
Red Oak, Iowa



Such an approach provides a reasonable model of the required telecommunications network facilities for two reasons. First, households and businesses typically reside near roads. Centering the road-reduced area about the center of the road network establishes network facilities closer to where customers are located than would the geographic center of the distribution quadrant. Second, rights of way for telecommunications structure generally exist near roadways. This approach reduces requisite network facilities, given customers' actual location.

SECTION 6.0

OUTSIDE PLANT METHODOLOGY

6.1 Overview

The loop module is designed to develop the loop costs associated with providing basic telephone service. BCPM 3.1 integrates more precise information regarding customer location than BCPM 1.1 with a customer location algorithm that establishes an optimal grid size based on an efficient network design.[28] Thus, the optimal grid size is determined by adhering to sound engineering practices that reflect forward looking, least cost technology for providing basic service. The "ultimate grid" is sized to comply with the technical requirements of a Carrier Serving Area (CSA). A CSA consists of a geographic area that can be served by a single digital loop carrier (DLC) site.

While BCPM 3.1 maintains some features of the loop engineering design in BCPM 1.1, the Model incorporates significant loop engineering changes to increase network efficiency. Recall that BCPM 1.1 squared the area encompassed by a CBG. For those CBGs with a density of less than 20 households per square mile, the squared CBG was reduced to a smaller square whose area is equivalent to the area encompassed within a 500 foot road buffer on each side of the roads within those low-density CBGs. BCPM 1.1 designed outside plant based on the assumption that customers are uniformly distributed throughout the road-reduced area.

BCPM 3.1 abandons the assumption in BCPM 1.1 that all customers are uniformly distributed throughout the CBG. BCPM 3.1's customer location algorithm uses housing and business line data at the Census Block (CB) level combined with information regarding the road network to more precisely locate customers. Utilizing all of this data, BCPM 3.1 models clusters of customers where they are indeed clustered and models sparsely populated areas where customers are, in fact, dispersed. This is all done while still retaining the shape and relative cable design of the wire center territory.

[28] See "Joint Comments of BellSouth Corporation, BellSouth Telecommunications Inc., U S WEST Inc., and Sprint Local Telephone Companies to Further Notice of Proposed Rulemaking Sections III.C.1", CC Docket 96-45 and CC Docket 97-160, filed Sept. 2, 1997.

Major changes to the BCPM 1.1 loop engineering include:

- directing main feeder toward population clusters, where appropriate;
- sharing of subfeeder, where appropriate;
- placing the DLC(s) at the road centroid of the grid;
- creating quadrants within the engineering area;
- running horizontal and vertical cables from the DLC site to each distribution area;
- placing the FDI at the road centroid of the quadrant where appropriate;
- allowing the road-reduced area to vary in size;
- permitting empty quadrants within grids, where appropriate;
- permitting sharing of the FDI between quadrants on either the left or right side;
- permitting co-location of the FDI with the DLC; and
- ensuring that the total cable length within a quadrant does not exceed the total road distance within that quadrant.

6.2 Engineering Standards

The engineering protocols most central to the design of this model include a maximum loop length for each CSA that is less than 12,000 feet. To ensure attainment of this standard, the maximum ultimate grid size is typically constrained to 1/25th of a degree latitude and longitude (approximately 12,000 feet by 14,000 feet). (Section 5.3.3 provides an in-depth discussion of BCPM 3.1's grid design.) The design of the ultimate grids ensures that the maximum copper loop length from the DLC site to the customer for any individual customer should not exceed 18,000 feet. A copper loop greater than 18,000 feet must be loaded or electronically extended at a substantial cost. The FCC clearly stated in its May 8, 1997 Order on Universal Service that no loaded loops are permitted.[29]

These constraints also ensure compliance with standard AT&T/Lucent and US LEC practices covering loop resistance and electrical (dB) loss.

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[29] FCC Report and Order, "In the Matter of Federal-State Joint Board on Universal Service," CC Docket No. 96-45, Released May 8, 1997, Paragraph 250, criterion 1 of the FCC's 10 criteria.

6.3 Feeder Design

The first step in designing the network is to create the feeder cable routes. This is done in the preprocessing portion of the modeling. Beginning at the wire center, a maximum of four main feeder[30] routes run directly east, directly north, directly west, and directly south from the wire center to serve four feeder quadrants. These routes run for 10,000 feet. This is based on the assumption that within 10,000 feet, customers are generally located within the perimeter of a town and that the town has some sort of gridded street complex. However, beyond 10,000 feet, the direction of each main feeder is determined by customer concentrations as reflected in the microgrid information data.

If the line count in the center 1/3 of a feeder quadrant is greater than 30% of the total feeder quadrant lines, this feeder remains a single feeder and potentially points to the population centroid of the entire feeder quadrant. The 30% figure is used to determine whether there is enough line demand in the middle to support the economics of a single feeder.

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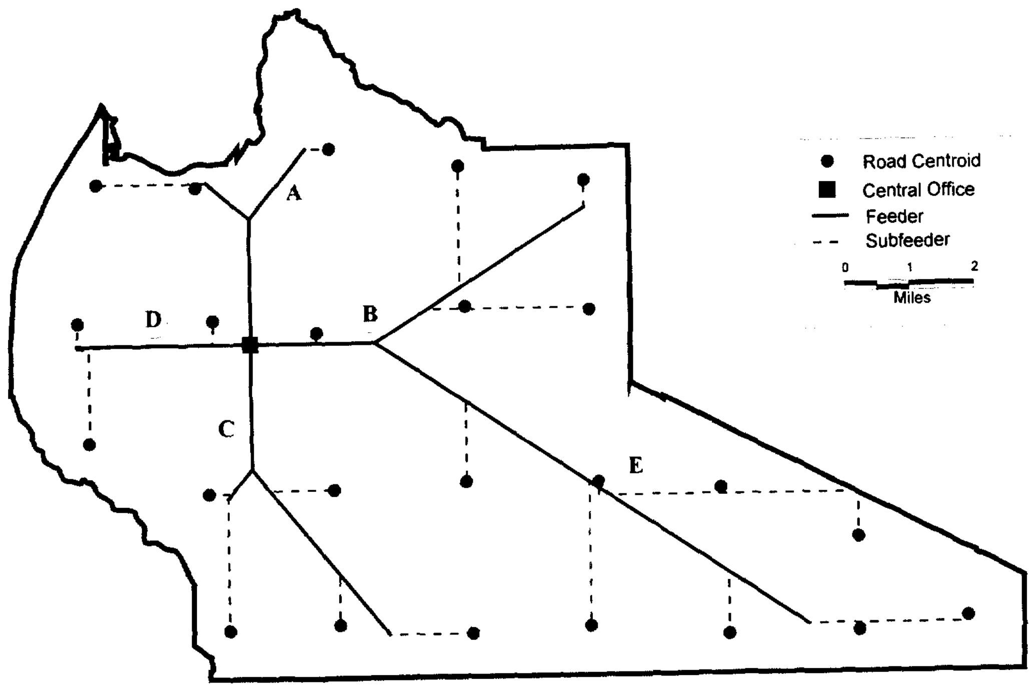
[30] There is a requirement for four main feeders. If due to the shape of the Wire center territory four feeders are not necessary, only the required number of feeders will be designed.

Figure 6.1
Feeder Plant
Glenville



If the line count in the center 1/3 of a feeder quadrant is less than 30% of the total feeder quadrant lines, the feeder splits into two main feeders, each potentially pointed at the population centroid in one half of the feeder quadrant. Each portion of the split main feeder is sized according to the number of customers that it serves. This modeling best depicts how a loop network is designed. This breakpoint should capture the need to split the cable to avoid any natural barriers. (An example of a split feeder is shown on the north directed main feeder (A), the east directed main feeder (B), and the south directed main feeder (C) in Figure 6.1). The length of the main feeder(s) is limited to the minimum distance necessary to reach the last subfeeder of an ultimate grid.

Anytime the model logic indicates that the main feeder should be redirected, or split, at the point 10,000 feet from the central office, a test is run to determine if the design produces the least cost network. Total feeder cable length (including feeder, subfeeder and sub feeder part two) for the redirected or split feeder system, potentially pointed to the population centroid, is compared with the total feeder cable length for a design where the main feeder is continued in the original cardinal direction, i.e. due north, south, east or west and subfeeders at right angles to the main. The design with the shortest total feeder cable length is selected.

6.4 Subfeeder Design

From the main feeder, subfeeders branch out toward the individual ultimate grids. Subfeeder is potentially shared by more than one ultimate grid. An example of this sharing is shown as area E in Figure 6.1.

Along a main feeder within 10,000 feet of the wire center, subfeeders may branch off the main feeder every 1/200th of a degree boundary.[31] For a single main feeder, i.e. a main feeder that does not split beyond 10,000 feet from the wire center, subfeeder branches upward or downward (vertically) from the main feeder in east and west feeder quadrants, and branches outward (horizontally) in north and south feeder quadrants. (See the west directed feeder (D) in Figure 6.1)

Along a main feeder beyond 10,000 feet of the wire center, subfeeder branches out at most, once between every 1/25th of a degree boundary. For a split main feeder that angles greater than 22 1/2 degrees from the direction of the original main feeder (away from the wire center), subfeeder emanates vertically upward or downward as appropriate, and horizontally outward away from the wire center, creating a fishbone pattern. For a split main feeder that angles less than 22 1/2 degrees from the original main feeder, subfeeder emanates outside of the subfeeder as explained above (away form the direction

[31] This corresponds to the boundaries of the underlying microgrids, i.e. the smallest grid size possible.

of the original main feeder cardinal line, i.e. due north, south, east or west) and emanates inside towards the cardinal line either horizontally for north and south directed main feeder or vertically for east and west directed main feeder. If the cardinal feeder line has extended from the 10,000 foot point, this interior subfeeder would create a right angle with the original cardinal line[32].

Subfeeder part 2 links subfeeder to the road centroid of an ultimate grid for those ultimate grids whose road centroid does not intersect the subfeeder. Thus, by definition, subfeeder part 2 is not shared by multiple ultimate grids.

A DLC site is established (where loop lengths exceed the copper/fiber breakpoint) within each CSA at the road centroid of the ultimate grid.[33] The number of DLCs placed at the DLC site depends on the number of lines served in that CSA.

If a CSA is served by copper feeder, the cross connect where copper feeder facilities are connected with copper distribution facilities (the feeder/distribution interface (FDI) site) is established at the road centroid for that ultimate grid.

Right and left connecting cables extend from the DLC location to the road centroid of each non-empty distribution quadrant. These connecting cables consist of horizontal connecting cables that extend east and west from the DLC site and vertical connecting cables that vertically connect the horizontal connecting cable to the road centroid of each of the non-empty distribution quadrants. Figure 6.2 shows an example of a grid distribution system with an empty quadrant.

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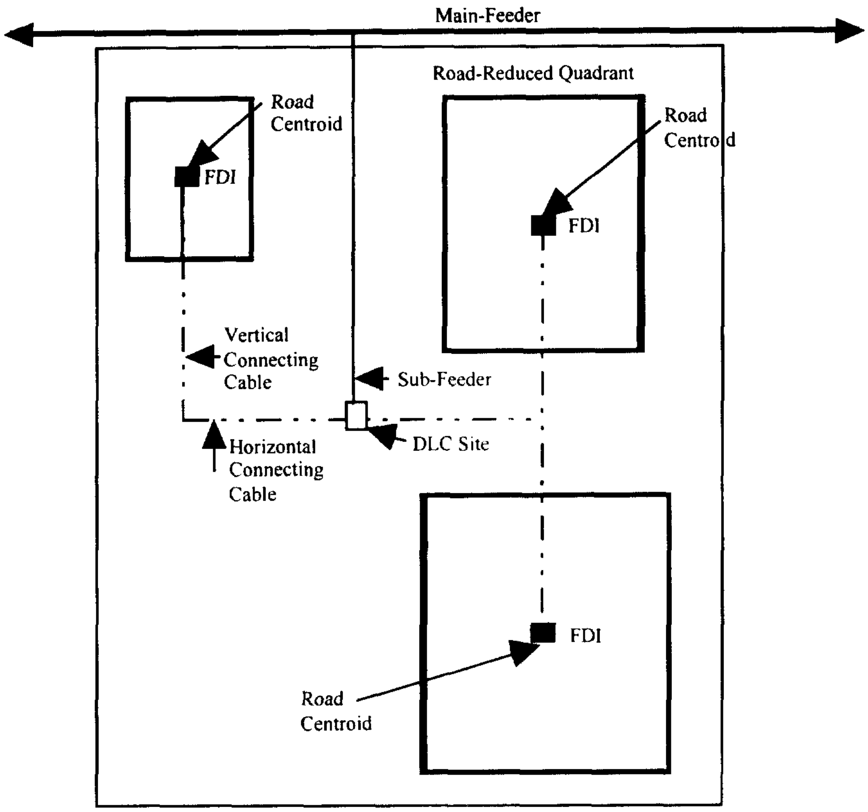
[32] In the case that both split feeders move at angles less that 22 1/2 degrees, the determination of which subfeeder serves grids that lie between the split feeders is made based on the shortest route to the road centroid of the grid.

[33] The road centroid is a point that represents the weighted average of the length of the roads within the defined area.

Figure 6.2
OUTSIDE PLANT DISTRIBUTION
Cabling to Quadrants



For purposes of summarizing plant investments, all cables connecting the DLC to remote FDIs are categorized as feeder, and any facilities that extend beyond the FDI to the customer are categorized as distribution plant.

6.5 Feeder Equipment

The Model allows for two DLC categories, each providing multiple size options of remote and central office terminal size. This permits placement of small DLCs in CSAs that serve a relatively small number of customers. Both large and small DLCs are assumed to be integrated DLC systems. In addition, the Model captures efficiencies garnered from large DLCs where appropriate. The decision to use either a small DLC or a large DLC is based on the number of lines the DLC can serve. Given an engineering fill factor of 90%, a small DLC is placed if the CSA serves less than 216 lines, i.e. 240 times 90%. This engineering fill factor is a user adjustable input.

A typical DLC remote cabinet size for a large DLC, such as the "Litespan-2000", can serve only up to 1,344 lines. BCPM places a second cabinet to complete a 2016 line system if applicable. Whether more DLCs are placed in that CSA depends on whether sound engineering practices call for another DLC or whether it is optimal to divide a grid further, into smaller ultimate grids, each representing a CSA. For example, it is possible for a single CSA to serve 5,000 customers if a large number of customers are located in a single office complex. In this case, multiple DLC cabinets/systems would be installed to provision the 5,000 lines.

6.6 Feeder Cable Requirements

The type of cable used in the feeder system is determined based on the specified copper/fiber breakpoint. The copper/fiber breakpoint is a user adjustable input.[34] The default input for the copper/fiber breakpoint is 12,000 feet. A copper/fiber breakpoint of 12,000 feet requires placing copper in the feeder if the maximum loop length from the wire center to all customers within an ultimate grid is less than 12,000 feet. If the loop length for any customer in the ultimate grid exceeds 12,000 feet, fiber is placed in the feeder to serve all customers in the ultimate grid. For all loops, cable beyond the DLC site is copper.

Feeder cables are sized to accommodate the number of working lines based on total residential, business, and special access lines. The size of feeder cables is based on the number of actual working lines adjusted by a variable engineering fill factor. For example, at an 85% engineering fill factor, a 400 pair cable can accommodate 340 working pairs before increasing the cable size. The default assumes a 75% engineering fill factor for the lowest density zone, an 80% engineering fill factor for the next two lowest density zones, and an 85% engineering fill factor for the remaining six density zones. These engineering fill factors for feeder cable are user adjustable inputs.

The required capacity for a segment of fiber feeder plant is determined in a similar manner. However, large DLC technology and small DLC technology cannot share fiber strands because of different transmission protocols. For large DLC systems, four fibers

[34] The Model allows the user to set the copper/fiber break point between 6,000 feet and 18,000 feet, given 3,000 foot increments.

can carry up to 2,016 voice grade paths. If the segment capacity exceeds this limit, four additional fibers are required for each increment of 2,016 voice grade paths. For small DLC systems, four fibers can carry up to 672 voice grade paths. Like large DLC systems, each additional increment of 672 voice grade paths capacity requires an additional four fibers. The voice grade paths are determined for each technology by summing the lines by Grid utilizing the particular technology and dividing the sum by the electronic fill factor.

The total capacity for a fiber feeder segment is the sum of the required large DLC fiber strands and required small DLC fiber strands. BCPM 3.1 determines the number of maximum size fiber cables and the size of the additional fiber cable to meet the capacity needs of the segment. The fiber feeder cable sizes available in the Model are 12, 18, 24, 36, 48, 60, 72, 96, 144, and 288 strands.

6.7 Distribution Plant Design

With the exception of the ultimate grids that remain microgrids in size, each ultimate grid, or equivalently, a CSA, is divided into four potential distribution quadrants.[35] The ultimate grid is quaded into four distribution quadrants at the road centroid of the ultimate grid which corresponds to the DLC site. Once the distribution quadrant is formed, data on the road network is used to determine the lengths of horizontal and vertical connecting cable and backbone and branch cable. For modeling purposes, a road-reduced area is developed as the area encompassed by a 500 foot buffer along each side of the livable roads (e.g., excluding limited access freeways and underpasses). While the road-reduced area is a simulation of reality, it is easy to conceptualize as a square centered about the road centroid of the distribution quadrant. The road-reduced area is equal to the area encompassed by a 500 foot buffer along each side of the roads within the distribution quadrant.[36] This is shown in Figure 5.5 in Section 5.3.4. No distribution facilities are placed within a distribution quadrant that

[35] Ultimate grids which are equivalent to a microgrid in size, are treated as a single distribution quadrant. This typically occurs in denser, urban areas.

[36] In cases where an ultimate grid remains the size of a microgrid, a 500 foot buffer along the roads within a microgrid typically corresponds to an area that is greater than the area of the microgrid. In such cases, the area is not reduced in size. The Model constrains the road-reduced area so that it does not exceed the area of the microgrid.